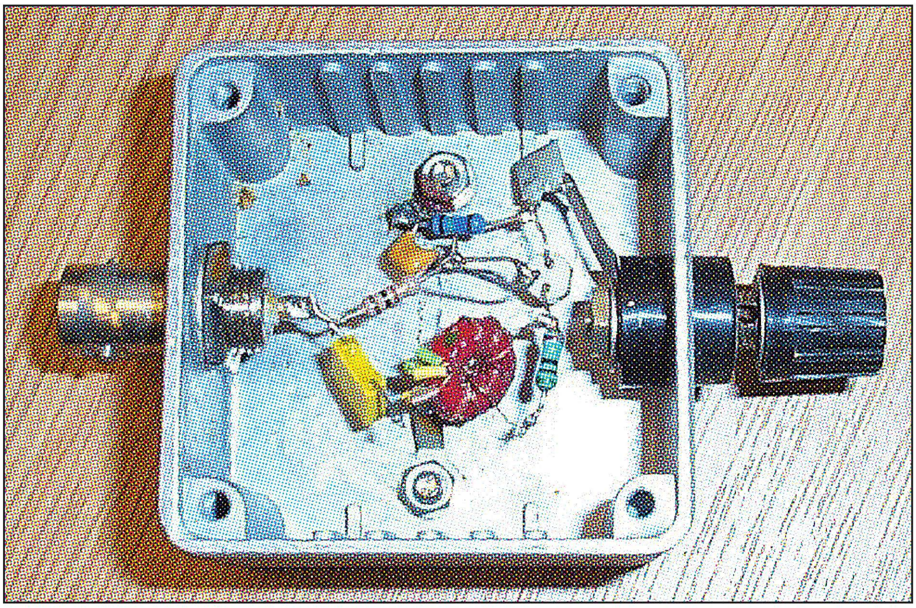
An Active Antenna for 160 to 4 metres

By Ian Braithwaite, G4COL *

THIS active antenna has been doing its job in my loft for well over 10 years. I've seen a number of designs over the years, and this is the simplest, deriving from experiment. When I recently saw a highly sophisticated-looking commercial unit, I felt it was time to 'go public'.

Active antennas rely on a combination of an antenna element (such as a dipole, monopole, or loop) and an amplifier, which is the 'active' part. The antenna element is non-resonant, and tends to be physically small. They have broad operating bandwidths, so don't need to be tuned. In comparison, a resonant antenna would need tuner adjustments to cover the whole HF and lower VHF spectrum. So, the attraction of active antennas is convenience.

It is only fair to point out that some people dislike them, and there are pitfalls, which I shall point out. If you want a really excellent receiving antenna for all the HF amateur and broadcast bands, and have masses of space, why not put up a Beverage or rhombic antenna? If, as in my case, that's out of the question, then consider an active antenna and, better still, try building your own! This one can be put together in a few hours and covers 160 to 4 metres.



The active antenna circuitry built into a diecast box.

DESIGN CONSIDERATIONS

THE CHOICE of a small antenna element (less than a tenth of a wavelength or so) is between the dipole and monopole, which respond to the electric field component of the radio wave; and the loop, which responds to the magnetic field component. A broadband active loop antenna is still on my list of things to try.

My first homebrew active antenna was a dipole, and was quite successful. The main thing it taught me was that it's not a good idea to have too much gain. It is natural to conclude that, as a short antenna picks up a smaller signal than a resonant dipole, the gain must be made up in the amplifier. Being a broadband device, the amplifier is subjected to the entire HF radio spectrum including powerful broadcast transmitters. What tends to happen in practice is that it distorts, generating intermodulation products. These appear to the receiver as additional signals and, though giving the impression of a 'lively' receiving system, are entirely unwanted. An attenuator between the active antenna and receiver is of no use at all, if the distortion has already happened in the active antenna.

It occurred to me to try a single wire monopole, which made for a simpler amplifier. This worked and has been in use ever since.

CIRCUIT DESCRIPTION

THE AMPLIFIER, shown in **Fig 1**, is a source-follower circuit designed around Tr1, a J310 FET (field-effect transistor). This has to present a high impedance to the small monopole, otherwise signal voltage is lost, and then deliver the signal to the receiver input, commonly a 50Ω impedance.

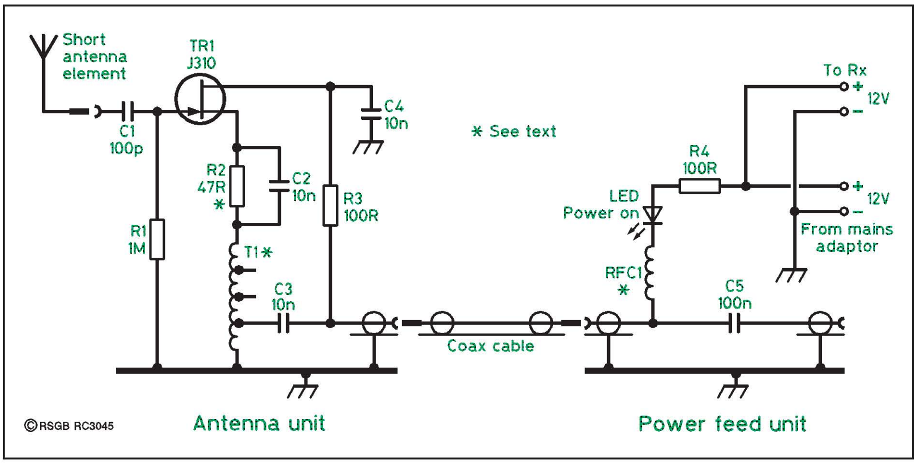


Fig 1: Circuit diagram of the antenna and power feed units.

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Maker	Maker's part no	Supplier
Amidon	FT37-61	JAB, Sycom
Amidon	FT50-61	JAB, Sycom
Philips (3C85 material)	433003037790	Farnell (stock code 178-504)

Table 1: Suitable toroidal cores and their suppliers.

The FET has an output impedance in the region of 50 to 100Ω, which means that, if the FET source fed the receiver 50Ω input, more than half the signal voltage would appear across the FET, and less than half would be delivered to the receiver. That's where the transformer T1, in the source circuit, comes in. I used a quadrifilar winding to give a 4:1 voltage step down ratio. This gives the source follower an overall gain of almost $^1/_5$ in voltage (-14dB when the ratio of gate voltage to output voltage is expressed in decibels).

The benefit of doing this is that the FET has much less work to do. The action of the transformer makes the impedance presented to the FET source bigger by a factor of 4^2 = 16 times, which is 800Ω. The result is improved linearity. Locations differ, but I have never known the active antenna produce unwanted signals. You may be concerned that this low gain would produce a rather 'deaf' receiving system but, from experience, comparing it to a transmitting dipole and tuner, you won't miss much, if anything. The internally-generated noise is very low, and the background noise in most of the HF spectrum is high.

Power to the active antenna is fed via the coaxial cable, and the supply is injected via choke RFC1 housed in the power-feed unit near the receiver. R4 is included to limit the current in the event of an accidental short-circuit. An LED in series with the supply indicates that current is being drawn, and protects against inadvertent supply polarity reversal. Shown on the circuit diagram is a power feed for a receiver. This is for the case where the receiver and antenna can share the same power supply. You may choose to omit it.

The frequency response is shown in **Fig 2**, and is nominally flat to within 1dB to 60MHz and within 2dB to 100MHz.

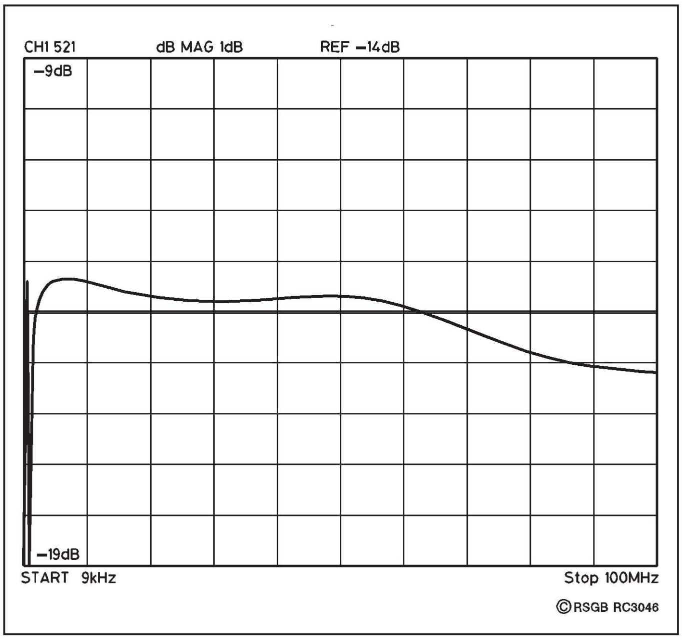
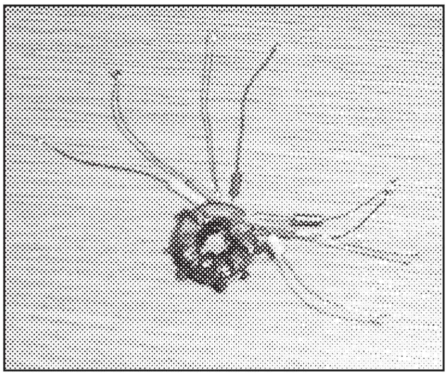


Fig 2: Frequency response of the active antenna.



Detail of the toroidal transformer, T1. Notice the placement of the individual turns, and their identification with coloured sleeving from ribbon (rainbow) cable.

CONSTRUCTION

TRANSFORMER T1 requires some care in construction, and is described in some detail, starting with the quadrifilar wire itself. This would probably be a labour-intensive and expensive item to produce commercially, and is where the amateur's craft skills come into their own.

Take four strands of 0.2mm diameter (35/36 SWG) enamelled copper wire, length approximately 300mm for each strand. Placing the wires side-by-side, clamp one end and, pulling the wires taut, fix the free end in the chuck of a hand drill. Turn the drill to twist the strands together. There is no need to twist too tightly, a few twists per centimetre being adequate.

The core should be a high-permeability (greater than 100) ferrite toroid, 10 to 15mm in diameter. The purpose of the core is to produce a sufficiently high inductance to avoid gain roll-off at low frequencies, and given a high enough permeability, a wide variety of types, still to be found at rallies, should be suitable. If you are buying new, **Table 1** shows the types that should be suitable. Supplier contact details are given at the end of the article. Between them, they should be able to source all items needed for construction.

Wind seven or eight turns of the quadrifilar wire on the core. (Each time the wire passes through the core counts as one turn.) The photograph shows how this has been done on a T37-61 core. To secure the winding, the core has been dipped in polyurethane varnish and left to dry.

The individual wires need to be separated and the windings identified. Each wire end should be stripped of its insulation. An easy way to do this is to hold the wire end in a blob of solder on the end of a soldering iron for a few seconds. Make sure you do this in a well-ventilated area and avoid inhaling the fumes or getting them in your eyes.

The ends of each winding can then be identified with a multimeter or continuity tester. I found it useful to mark the windings with short strips of insulation stripped from ribbon cable, and slid over the wires as shown in the same photograph. If you do this with three windings, the fourth can be left plain.

Naming the windings arbitrarily 1 to 4, take the *end* of winding 1, and twist together with the *start* of winding 2. The *end* of 2 is then twisted with the *start* of 3, and so on. Twist fairly close to the toroid, and make electrical connection using the soldering iron, as described above, observing the precautions. The transformer is now complete. Check for electrical continuity through the whole transformer by measuring across the un-paired wires.

Once the transformer is done, the rest of the construction is straightforward. Start with R2 as 47Ω or 68Ω. It may need to be changed on test. The photograph on p 52 shows my loft unit built into a diecast box, with a couple of solder tags for earthing to the box. Alternatively, the circuit can be built above a small piece of plain copper-clad board, which can then be fitted inside a weatherproof enclosure if outdoor mounting is required. The enclosure itself can be plastic - it is an antenna after all!

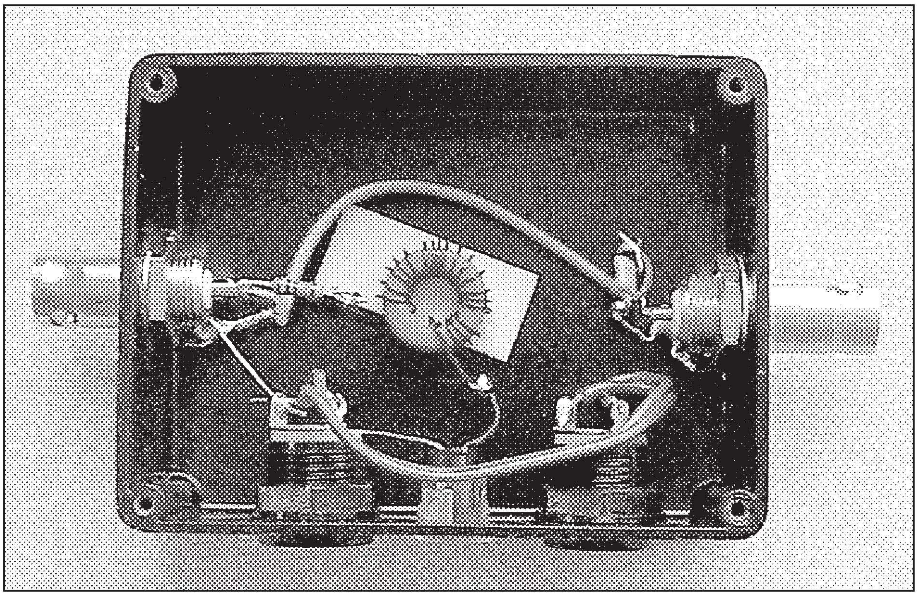
Make sure you select the correct tap on transformer T1 for the output, and take care to prevent the unused taps from shorting to any other part of the circuit.

COMPONENTS LIST

Positive supply (negative earth) version		Negative supply (positive earth) version		Miscellaneous
Resistors (0.25-watt metal film)		**Resistors (0.25-watt metal film)**		Enclosures
R1	1MΩ	R1	1MΩ	BNC or favoured sockets
R2	see text	R2	see text	4mm terminal post
R3, 4	100Ω	R3	100Ω	Power connectors
				Solder tags
				Nuts & bolts
Capacitors		**Capacitors**		**Supplier details:**
C1	100pF ceramic plate	C1	100pF ceramic plate	**Farnell**: Canal Road, Leeds LS12 2TU. Tel: 0113 263 6311.
C2, 3, 4	10nF ceramic disc	C2, 3	10nF ceramic disc	
C5	100nF ceramic disc	C4	100nF ceramic disc	**JAB**: PO Box 5774, Birmingham B44 8PJ. Tel: 0121 682 7045. Fax: 0121 681 1329.
Inductors		**Inductors**		
T1	see text	T1	see text	
RFC1	20 turns on high-permeability toroid	RFC1	20 turns on high-permeability toroid	**Sycom**: PO Box 148, Leatherhead, Surrey KT22 9YW. Tel: 01372 372 587. Fax: 01372 361 421. www.sycomcomp.co.uk
Semiconductors		**Semiconductors**		
Tr1	J310	Tr1	J310	
LED	Red or chosen colour	LED	Red or chosen colour	

THE POWER FEED

AS THE PHOTOGRAPH (right) illustrates, I built my power feed unit in a small plastic box. The choke is a single winding of around 20 turns on another high permeability toroid, which can be the same type as that used for the transformer. A metal enclosure would make sense for the power feed unit, since it will be near the receiver and possibly also domestic interference sources. If using a plastic housing, link the coaxial sockets with coaxial cable: I used some RG178. Keep the braid 'tails' short to avoid unwanted pickup.



The power feed unit.

TESTING AND COMMISSIONING

CHECK CAREFULLY for wiring errors. For bench testing, the power feed and antenna units can be linked with a short coaxial cable. Having ensured that its voltage and polarity are correct, connect the power supply and check that the LED is lit. Measure the voltage across R2 and divide this by its resistance to find the current, or measure the supply current directly. This should be in the region of 10 to 20mA. I selected R2 for a current of around 15mA.

If the power feed output is now connected to a receiver, a small amount of additional hiss should be heard. Nothing should be heard until a short wire (1 metre or less) is placed on the antenna input. Signals should be heard on the HF bands, given suitable propagation conditions, or perhaps television or PC monitor timebase harmonics.

The antenna unit should be installed as high and as far away from local sources of interference as practicable. Mine is at the apex of the loft, with an antenna wire of around 1 metre length, suspended from a hook in the highest beam. Avoid the temptation to increase the wire length excessively in order to increase the signal. This brings the risk of distortion, and departure from a flat gain with frequency.

POSITIVE - EARTH VERSION

WITH A NEGATIVE supply and positive earth, a couple of components can be omitted. This is shown in **Fig 3**, below. However, note that, while this is fine on its own, *it must not be connected to a receiver with a negative earth, because this shorts out the supply*. ♦

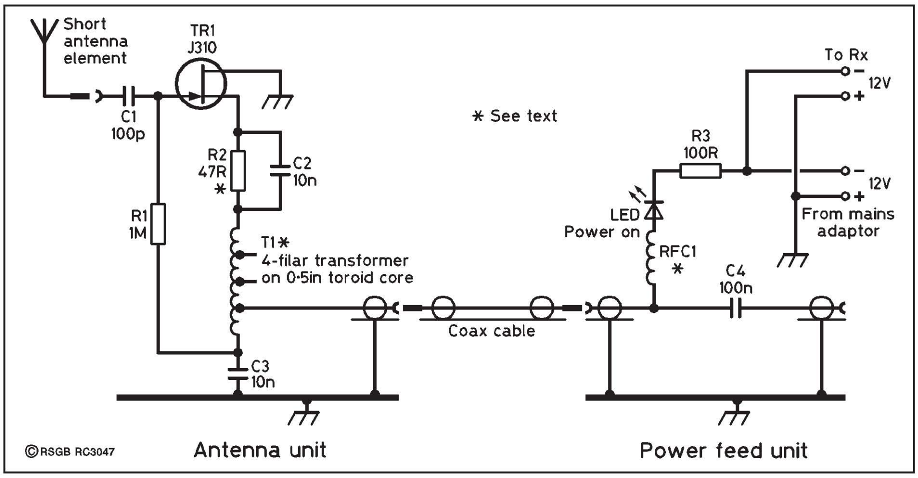


Fig 3: Circuit diagram of the antenna and power feed units for a positive - earth version.